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NATIONAL DAM SAFETY PROGRAM. TWIN LAKE DAM (MO 10476), MISSOURI--ETC(U)
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TWIN LAKE DAM
MERCER COUNTY, MISSOURI
MO 10476

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM



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PREPARED BY: HOSKINS-WESTERN-SONDEREGGER, INC.
FOR: STATE OF MISSOURI

JULY, 1978

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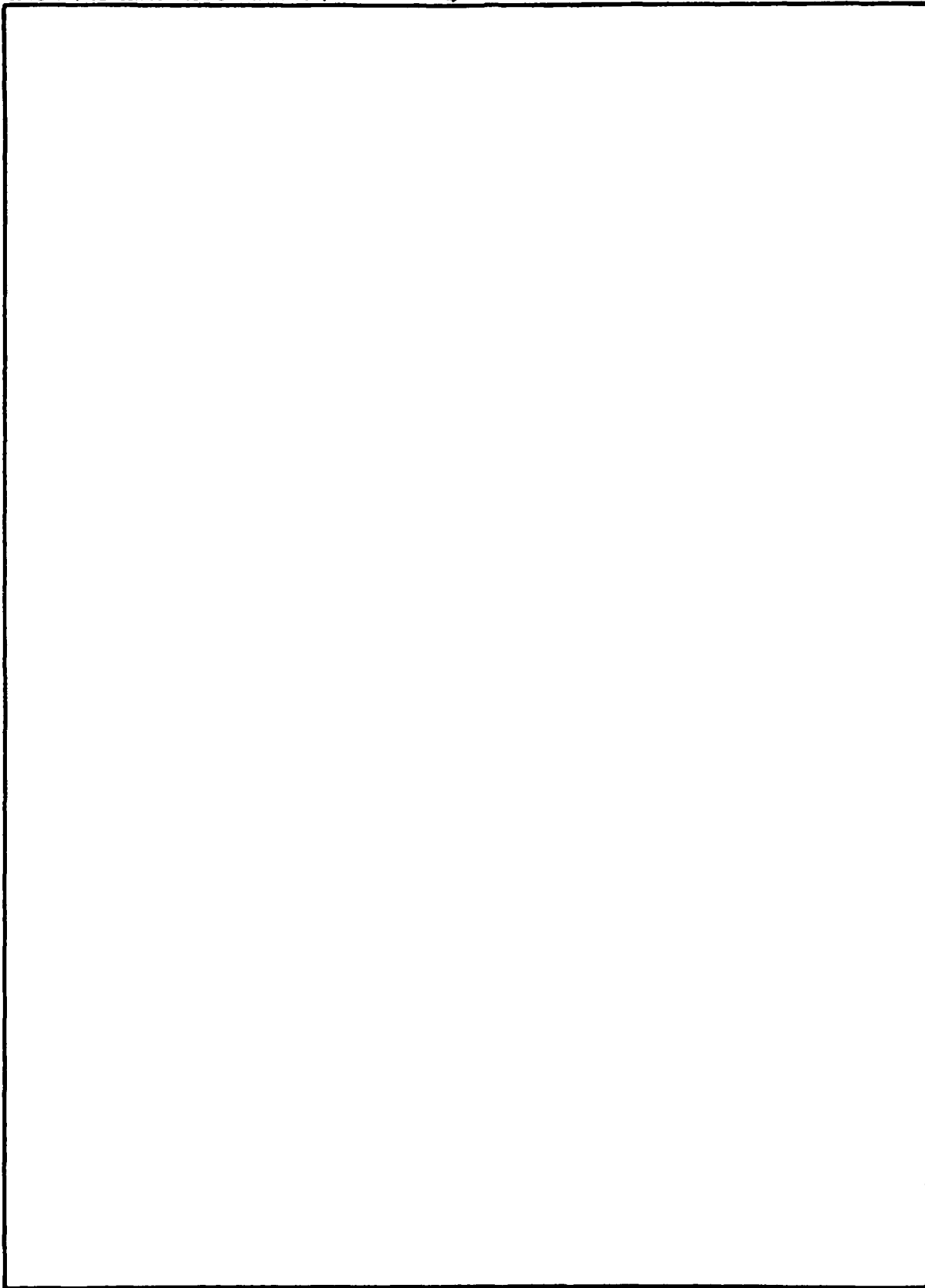
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PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam	Twin Lake Dam
State Located	Missouri
County Located	Mercer County
Stream	Pops Branch
Date of Inspection	July 14, 1978

Twin Lake Dam was inspected by an interdisciplinary team of engineers from Hoskins-Western-Sonderregger, Inc. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers and developed with the help of several Federal and State agencies, professional engineering organizations, and private engineers. Based on these guidelines, this dam is classified as an intermediate size dam with a high downstream hazard potential. Failure would threaten life and property. The estimated damage zone extends four miles downstream of the dam. Hidden Valley Lake Dam (MO 10665) is approximately one-half mile downstream of Twin Lake Dam. Within the damage zone are a sewage lagoon located at the foot of Twin Lake Dam, four mobile homes located on Hidden Valley Lake, Hidden Valley Lake Dam, five mobile homes and one farmhouse with outbuildings located downstream from Hidden Valley Lake Dam.

Our inspection and evaluation indicates that the spillways do not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The spillways will pass 53% of the Probable Maximum Flood without overtopping the dam. The Probable Maximum Flood (PMF) is defined as the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. An additional deficiency, in accordance with the guidelines, is the lack of seepage analysis. These analyses should be obtained in the future.

The present maintenance practices appear to be satisfactory and should be continued by the owner. Copies of the report have been furnished the dam owner and the Governor of Missouri.

H. P. Hoskins E 8696
Harold P. Hoskins, P.E.
Hoskins-Western-Sonderregger, Inc.
Lincoln, Nebraska

SUBMITTED BY

SIGNED

Chief, Engineering Division

25 SEP 1978

Date

APPROVED BY

SIGNED

Colonel, CE, District Engineer

25 SEP

Date

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PHOTO NO. 1
OVERVIEW
LOOKING TO SOUTHWEST
DAM IN BACKGROUND

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
TWIN LAKE DAM - MO 10476

TABLE OF CONTENTS

<u>Paragraph No.</u>	<u>Title</u>	<u>Page No.</u>
SECTION 1 - PROJECT INFORMATION		
1.1	General	1
1.2	Description of Project	1
1.3	Pertinent Data	2
SECTION 2 - ENGINEERING DATA		
2.1	Design	5
2.2	Construction	5
2.3	Operation	5
2.4	Evaluation	5
SECTION 3 - VISUAL INSPECTION		
3.1	Findings	6
3.2	Evaluation	7
SECTION 4 - OPERATIONAL PROCEDURES		
4.1	Procedures	8
4.2	Maintenance of Dam	8
4.3	Maintenance of Operating Facilities	8
4.4	Description of Any Warning System in Effect	8
4.5	Evaluation	8
SECTION 5 - HYDRAULIC/HYDROLOGIC		
5.1	Evaluation of Features	9
SECTION 6 - STRUCTURAL STABILITY		
6.1	Evaluation of Structural Stability	11
SECTION 7 - ASSESSMENT/REMEDIAL MEASURES		
7.1	Dam Assessment	12
7.2	Remedial Measures	12

APPENDIX A - MAPS

Plate 1	Vicinity Topography
Plate 2	Location Map
Plate 3	Orthophotograph

APPENDIX B - PHOTOGRAPHS

Photographs of Dam and Lake (No. 2 through No. 10)

APPENDIX C - PLANS AND REPORTS

Twin Lake Dam	Plan and Cross Section
Phase I	Sections, Profiles and
	Spillway Plan

APPENDIX D - HYDROLOGIC COMPUTATIONS

Plate D1	Inflow Hydrographs -
	1/2 PMF and PMF
Plate D2	Inflow Hydrograph -
	100-year

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, District Engineer directed that a safety inspection of the Twin Lake Dam be made.

b. Purpose of Inspection. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

c. Evaluation Criteria. Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, in "Recommended Guidelines for Safety Inspection of Dams." These guidelines were developed with the help of several Federal agencies and many State agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances.

(1) The dam is an earth structure constructed on the same drainage-way and about 0.8 mile downstream from Berndt Lake. Discharges from this project flow into Hidden Valley Lake about 1,000 feet downstream from the Twin Lake dam. The topography of the area adjacent to the dam and reservoir is gently rolling. Soils in the area are derived from fine grained, plastic glacial till.

(2) Uncontrolled spillways are excavated into the abutments on both ends of the dam. The crest of the primary spillway on the left (east) end is approximately 2 feet lower in elevation than the crest of the secondary spillway on the right end.

(3) The upper of three diked sewage lagoons is located near the outlet channel of the right (west) spillway.

(4) A controlled discharge system, installed to supply domestic water, consists of an 8 inch diameter steel pipe passing through the base of the dam with control valves at the outlet end.

(5) Pertinent physical data are given in paragraph 1.3 below.

b. Location: The dam is located in the north-central portion of Mercer County, Missouri, as shown on Plate 2. The lake formed by the dam is shown on Plate 1 in the NW¼ of Sec. 31, T66N, R23W and SW¼ of Sec. 30, T66N, R23W. The lake is also shown on the Princeton NE Orthophotograph (Plate 3).

c. Size Classification. Criteria for determining the size classification of dams and impoundments are presented in the guidelines referenced in paragraph 1.1c above. Based on these criteria, this dam and impoundment is in the intermediate size category.

d. Hazard Classification. Guidelines for determining hazard classification are presented in the same guidelines as referenced in paragraph c above. Based on referenced guidelines, this dam is in the High Hazard Classification. The estimated damage zone extends four miles downstream of the dam. Hidden Valley Lake Dam (MO 10665) is approximately one-half mile downstream of Twin Lake Dam. Within the damage zone are a sewage lagoon located at the foot of Twin Lake Dam, four mobile homes located on Hidden Valley Lake, Hidden Valley Lake Dam, five mobile homes and one farmhouse with outbuildings located downstream from Hidden Valley Lake Dam.

e. Ownership. This dam is owned by Hubert Berndt, Mercer, Missouri 64661.

f. Purpose of Dam. The dam forms a 58 acre recreational lake.

g. Design and Construction History. According to the owners, the dam was constructed in 1971-1972. Geologic and soil engineering investigations and analyses were performed by Lane Western, Inc. of Kansas City and soil engineering design recommendations were included in a report dated July, 1969. Construction was supervised by the owner.

h. Normal Operating Procedure. The spillways for this dam are uncontrolled. The controlled discharge system is not utilized for water supply at this time. It was reported that no flows have passed through the spillways.

1.3 PERTINENT DATA

a. Drainage Area

(1) Total Area - 600 acres (includes Berndt Lake, No. Mo. 10472).

(2) Twin Lake Area only - 407 acres.

b. Discharge at Damsite

(1) All discharge at the damsite is through uncontrolled spillways excavated into abutments on both ends.

(2) A controlled discharge system consisting of an 8" diameter steel pipe passing thru the base of the dam is operable but presently not in use.

(3) Estimated maximum flood at damsite - unknown.

(4) Estimated ungated primary spillway capacity at maximum pool elevation (963.4[±]) - 1,592 c.f.s.

(5) Estimated ungated secondary spillway capacity at maximum pool elevation (963.4[±]) - 221 c.f.s.

(6) The total spillway capacity at maximum pool elevation - 1,813 c.f.s.

c. Elevation (Feet above M.S.L.).

(1) Top of dam - 964[±].

(2) Spillway crest: Left - 960[±];
Right - 962[±].

(3) Streambed at centerline of dam - 903[±].

(4) Maximum tailwater - unknown.

d. Reservoir. Length of maximum pool - 3,700 feet [±].

e. Storage (Acre-feet). Top of dam - 1,360.

f. Reservoir Surface (Acres).

(1) Top of dam - 69 acres [±].

(2) Primary spillway crest - 58 acres [±].

g. Dam

(1) Type - Homogeneous earth fill.

(2) Length - 800 feet [±].

(3) Height - 62 feet [±].

(4) Top width - 24 feet [±].

(5) Side Slopes -

(a) Downstream - 2.5H on 1V (measured with Abney hand level).

- (b) Upstream - 2H on 1V.
- (6) Zoning - no.
- (7) Impervious core - no.
- (8) Cutoff - Reported to be a 10 foot wide cutoff, 2 to 3 feet deep on each side of the centerline of the dam.

- (9) Grout curtain - no.
- (10) Wave protection - Riprap on upstream slope.
- (11) Foundation/toe drain - no.

h. Diversion and Regulating Tunnel. None.

i. Spillway.

(1) Primary.

(a) Type - earth channel plated with loose limestone rock.

(b) Control section - 64 foot bottom width 5:1⁺ side slopes.

(c) Crest elevation - 960 feet ⁺ m.s.l.

(2) Secondary.

(a) Type - grassed earth channel.

(b) Control section - gravel access road.

(c) Crest elevation - 962 feet ⁺ m.s.l.

(d) Downstream channel - a small farm pond and lagoon system are located downstream of exit channel.

j. Regulating Outlets

An 8 inch diameter steel pipe with a submerged inlet and a 6 inch valve at the outlet is the only regulating outlet. This outlet was installed to supply domestic water to development around the lake but the need was eliminated. This outlet is not considered in the hydrologic analysis of the dam.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

The owner has a copy of a soil engineering report for this structure prepared by Lane Western, Inc., Kansas City. This report was reviewed at the time of the inspection. Soil Engineering design parameters and procedures seemed realistic and adequate. Slope stability analyses were included in the report with factors of safety of 1.59 for the 2H on 1V upstream slope and 1.5 for the 2.5H on 1V downstream slope. The report recommended a blanket drain under the downstream section.

A rough drawing of the dam, conceived and prepared by the owner is shown in Appendix C.

Topographic data to evaluate reservoir stage-volume relationships were taken from U.S. Geological Survey 15 minute quadrangle sheets enlarged to the equivalent scale of 7.5 minute quads with 20 ft. contour interval.

2.2 CONSTRUCTION

Construction of the dam was completed in 1970. Embankment slopes were constructed in accordance with the soil engineering report. The owner reported that the recommended drains were not needed and not installed. The riser-conduit spillway shown on the owner's drawing was not installed. The owner reported that the dam was constructed in 6 to 8 inch lifts and compacted at near optimum moisture content with sheeps foot rollers. Borrow material for the dam consisted of clay and sandy clay.

2.3 OPERATION

The owner reported that water has not passed through the uncontrolled spillways.

2.4 EVALUATION

a. Availability. A soil engineering report for this structure is available from the owner. The only plans that were available are those shown in Appendix C. Information on construction was supplied by the owner.

b. Adequacy. The data available in the soil engineering report and provided by the owner are considered adequate to evaluate the design and construction of this dam.

c. Validity. Data that were available are considered to be valid.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of Twin Lakes Dam was made on July 14, 1978. Personnel making the inspection were Rey Decker and Steve Nickel, Geology and Soil Engineering; Garold Ulmer, Civil Engineer; and Richard Walker, Hydrology. All of the above team are employees of Hoskins-Western-Sonderegger, Inc., Lincoln, Nebraska. Mr. Hubert Berndt, owner of the dam, supplied information on design, construction and operation of the dam.

b. Dam. The dam looks very good. The upstream slope is riprapped to an elevation about 3 feet below the crest of the dam. The riprap appeared to be in good shape. No slips or significant erosion were noted on the upstream face. The crest and downstream slope is well vegetated with grass and well maintained. Materials on the surface of the dam consist of lean clay and sandy clay (CL and SC). No slides, significant erosion, or deformations were noted on the downstream slope.

No seepage or evidence of the phreatic line outcropping was observed on the downstream slope. A small seep area was observed at the toe of the dam opposite about centerline station 4+00.

Abutment materials consist of fine grained plastic glacial till. No seeps, other than downstream from \pm station 4+00 \pm , slides or significant erosion were noted in the abutments.

Rough measurements of the centerline profile and a typical cross section of the dam indicate that it was constructed according to Lane Western recommendations. Measured sections are shown in Appendix C.

c. Appurtenant Structures.

(1) The primary spillway (uncontrolled) is cut through the glacial till abutment on the left (east) end of the dam. The spillway has a bottom width of 64 feet \pm with the crest at elevation 960 \pm . The inlet section is unobstructed. The water surface in the reservoir was slightly below crest elevation at the time of the inspection. The exit channel extends south-westward from the dam for a distance of 350 to 400 feet where it dumps into a side drainageway. Discharge through this spillway will enter the creek channel about 300 feet below the toe of the dam. The entire bottom of the spillway is plated with loose limestone rock which has a maximum size of about 12 inches in diameter. No slides, slumps or significant erosion were noted in this spillway.

1

(2) A secondary spillway is cut into glacial till on the right (west) abutment. The access road to the dam provides the control section for this spillway with a crest elevation of $962\pm$. A small farm pond is located near the south end of the exit channel for this spillway (about 165 ft. downstream from $\frac{1}{2}$ of dam). The crest elevation of the embankment for the farm pond is 960 feet \pm with the water level at about $958\pm$. The north end of a large sewage lagoon (700 feet \pm long-north to south and 365 feet \pm wide-east to west) is located immediately east and down slope from the farm pond. The crest elevation of the dike around the lagoon is at 957 feet \pm . Water surface in the lagoon is at elevation 954 feet \pm . Two smaller lagoons are located southeast of the large lagoon. The water surface in these lagoons is reported to be 2 feet and 6 feet lower than the large lagoon. Rough measurements and sketches of the secondary spillway and adjoining ponds are shown in Appendix C.

Rough measurements along the centerline of the secondary spillway indicate that most flows will be carried around the right end of Twin Lake Dam and discharged eastward into a small drainageway passing between the roadway along the toe of the dam and the dike forming the sewage lagoon. It appeared that high flows of sustained duration could cause significant erosion along the toe of Twin Lake Dam and along the base of the lagoon dike.

The discharge from the spillways of Twin Lake Dam flow into Hidden Valley Lake located about 1,000 feet downstream from Twin Lake.

(3) The controlled discharge system for this dam was installed to supply domestic water for the development. The services of a Rural Water System have temporarily eliminated this need. The system consists of a submerged inlet (not evident during the inspection) and a steel pipeline 8 inches in diameter passing under the base of the dam. Discharge is controlled by a 6 inch valve at the outlet end of the pipeline located 40 to 50 feet downstream from the toe of the dam opposite about centerline station 3+50.

d. Reservoir Area. Some erosion was observed along the east shoreline 300 to 400 feet upstream from the dam. No significant erosion was noted on the remainder of the shoreline. No slides or slips were noted around the shoreline.

e. Downstream Channel. The outlet channel downstream from the left (east) spillway is lined with trees and appeared to be stable. The conditions downstream from the right (west) spillway are discussed in paragraph 3.1 c(2).

3.2 EVALUATION

None of the conditions observed indicate a serious potential of failure. Additional surveys and studies would be required to determine the potential damages to the Twin Lake Dam and/or the adjacent sewage lagoon that might result from maximum discharges through the right (west) spillway.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

No operational procedures exist for this dam. The controlled discharge system is not presently utilized for water supply as intended in the original development.

4.2 MAINTENANCE OF DAM

The dam is well maintained.

4.3 MAINTENANCE OF OPERATING FACILITIES

The controlled discharge system is operable.

4.4 DESCRIPTION OF WARNING SYSTEM IN EFFECT

No warning system exists for this dam.

4.5 EVALUATION

The maintenance and operation of the dam and appurtenances seems to be adequate.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. No original hydrologic data was received from the owner.

b. Experience Data. The drainage area and lake surface area are developed from U.S.G.S. Princeton, Mo. (15') Quadrangle. The spillway and dam layout are from surveys made during the inspection.

c. Visual Observations.

(1) The primary and secondary spillways appeared to be in good condition.

(2) The secondary spillway is located at the right abutment of the dam. Immediately downstream of the exit channel is a lagoon system. It is uncertain as to what effect, if any, the discharge from spillway will have on stability of the lagoon system.

(3) The primary spillway is located at the left abutment of the dam.

d. Overtopping Potential. The spillways are too small to pass the probable maximum flood without overtopping. The spillways will pass the 53% PMF before overtopping occurs. The spillways will pass the one-half PMF and the 100-year frequency flood without overtopping. The results of the routings through the dam are tabulated in regards to the following conditions.

<u>Frequency</u>	<u>Inflow Discharge c.f.s.</u>	<u>Outflow Discharge c.f.s.</u>	<u>Maximum Pool Elevation</u>	<u>Freeboard Top of Dam Min. Elev. 963.4</u>	<u>Time Dam Overtopping Hr.</u>
100 Yr.	834	498	961.79	+ 1.61	0
1/2 PMF	2312	1568	963.20	+ 0.02	0
PMF	5160	5109	964.72	- 1.32	2½
* 53% PMF	2514	1784	963.4	0	0

*Figures obtained from interpolation between 0.5 and 0.6 PMF.

According to the recommended guidelines from the Department of the Army, Office of the Chief of Engineers, this dam is classified as having a high hazard rating and an intermediate size. Therefore, the PMF is the test for the adequacy of the dam and its spillways.

The St. Louis District, Corps of Engineers, in a letter dated 13 July 1978, has estimated the damage zone for this dam.

The estimated damage zone extends four miles downstream of the dam. Hidden Valley Lake Dam (Mo 10665) is approximately one-half mile downstream of Twin Lake Dam. Within the damage zone are a sewage lagoon located at the foot of Twin Lake Dam, four mobile homes located on Hidden Valley Lake, Hidden Valley Lake Dam, five mobile homes and one farmhouse with outbuildings located downstream from Hidden Valley Lake Dam.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations which could adversely affect the structural stability of this dam are discussed in Section 3.

b. Design and Construction Data. Available data and information indicate that this dam is structurally stable.

c. Operating Records. No operating records were available except the report that no flows have passed over the spillways.

d. Post Construction Changes. The sewage lagoons and the farm pond at the outlet of the right spillway were constructed after Twin Lake Dam was completed. The possible affect of these features on structural stability of the dam are discussed in Section 3.

e. Seismic Stability. This dam is located in Seismic Zone 1. An earthquake of this magnitude is not expected to affect the structural stability of this dam.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. The only feature noted during the visual inspection that might affect the safety of this dam is the potential damage that might result from maximum, sustained discharge through the right (west) spillway. The seepage in one small area below the toe of the dam is considered normal and not hazardous to the stability of the structure. According to the approximate reservoir stage-storage relationships used for flood routings reported in Section 5, the probable maximum flood will overtop the dam but the spillways will pass the flood expected once in 100 years and will pass 53 percent of the probable maximum flood without overtopping.

b. Adequacy of Information. The available information on design and construction is considered adequate to assess the stability of the structure. Seepage analyses were not found which is a deficiency that should be corrected in the future.

c. Urgency. There is no immediate urgency to accomplish the remedial measures discussed in paragraph 7.2.

d. Necessity for Phase II. Phase II investigations are not considered necessary for this dam.

e. Seismic Stability. An earthquake of the magnitude expected in Seismic Zone 1, where this dam is located, should not be hazardous to this dam.

7.2 REMEDIAL MEASURES

a. Alternatives.

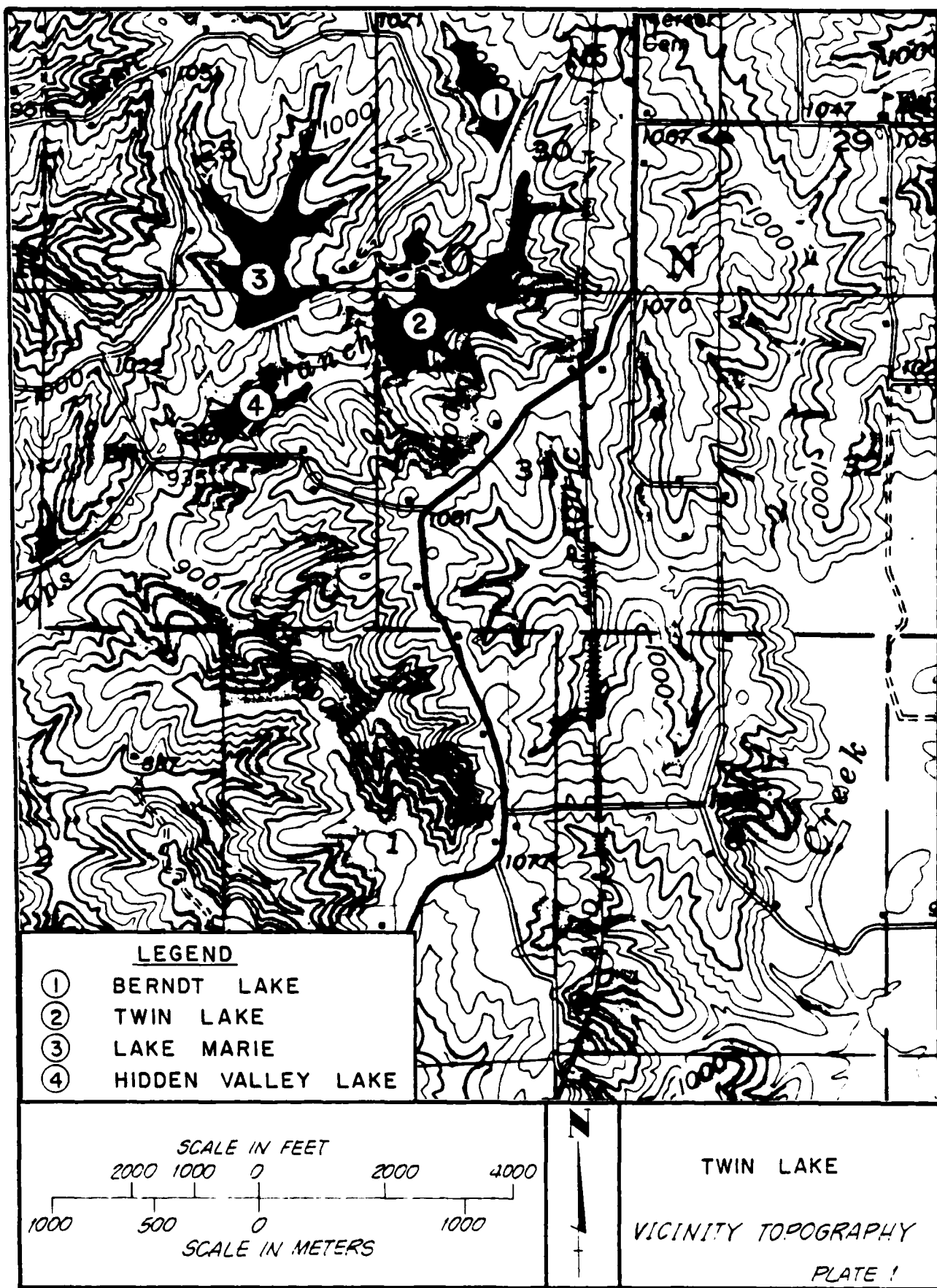
(1) The size of the primary spillway on the left end of the dam should be increased to pass the probable maximum flood.

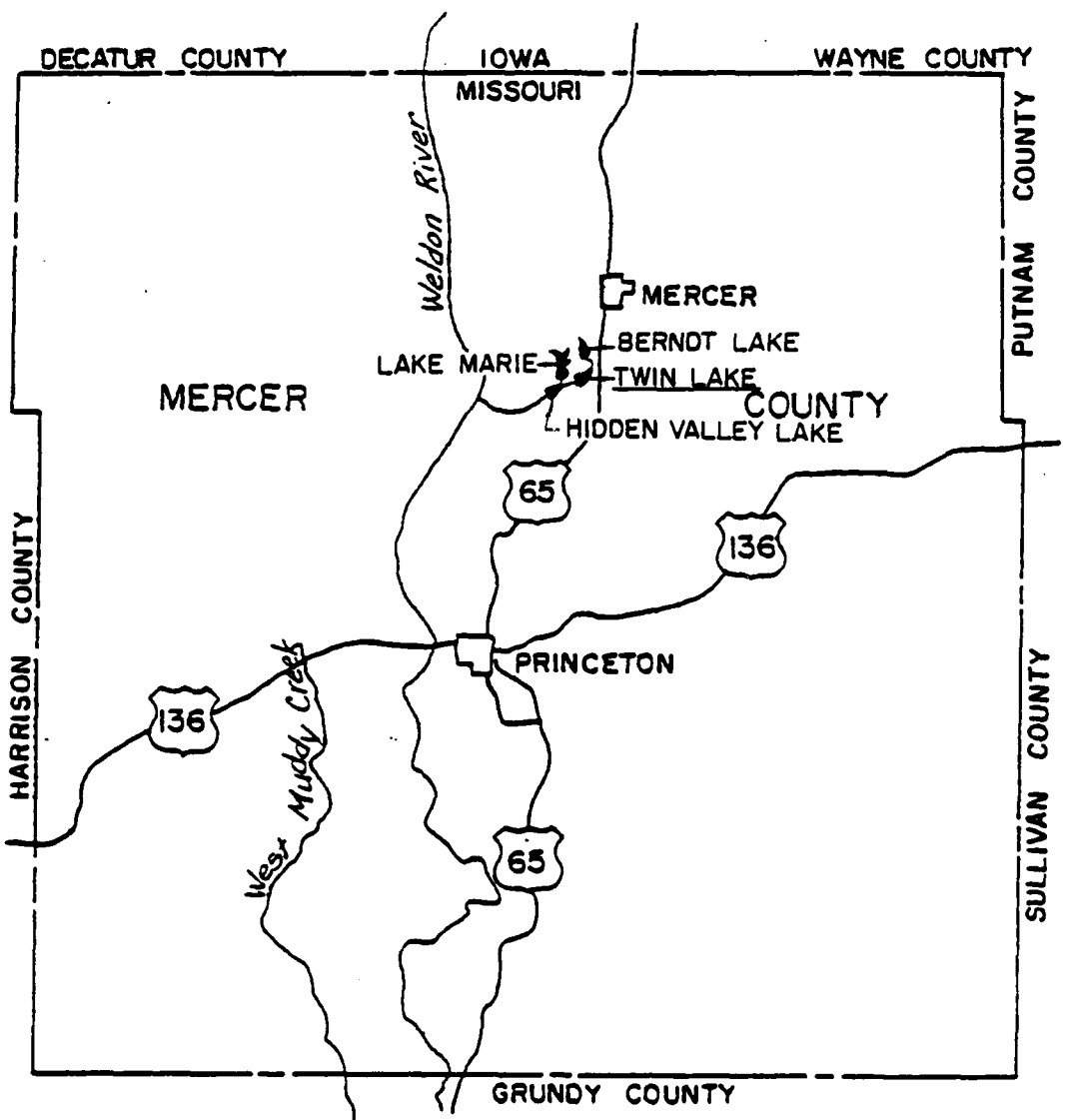
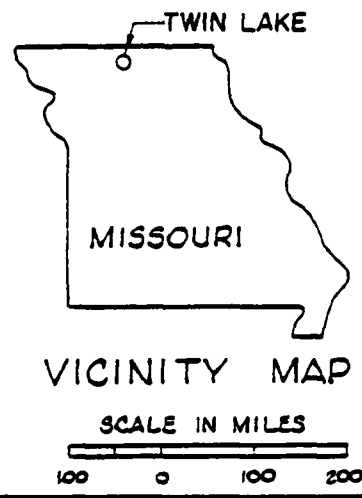
(2) Measures should be installed to insure that discharge through the right spillway will not endanger the stability of the Twin Lake Dam or the adjoining sewage lagoon.

b. O&M Maintenance and Procedures.

The present maintenance practices and procedures appear to be satisfactory and should be continued.

APPENDIX A
MAPS





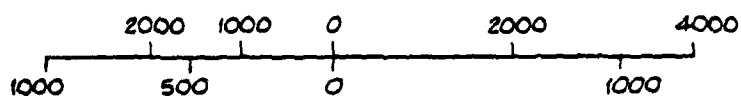
LOCATION MAP
PLATE 2



LEGEND

- ① BERNDT LAKE
- ② TWIN LAKE
- ③ LAKE MARIE
- ④ HIDDEN VALLEY LAKE

SCALE IN FEET



SCALE IN METERS



TWIN LAKE
ORTHOPHOTOGRAPH
PLATE 3

APPENDIX B
PHOTOGRAPHS

PHOTO NO. 2
LOOKING UP LEFT
SPILLWAY FROM
STA. 1+28



PHOTO NO. 3
LOOKING DOWN RIGHT
SPILLWAY FROM 140'
NORTH OF CENTERLINE
OF DAM



PHOTO NO. 4
UPSTREAM SLOPE
FROM RIGHT SPILLWAY





PHOTO NO. 5
LOOKING OVER
FIRST LAGOON
FROM RIGHT
ABUTMENT. MEN
STANDING IN RIGHT
SPILLWAY

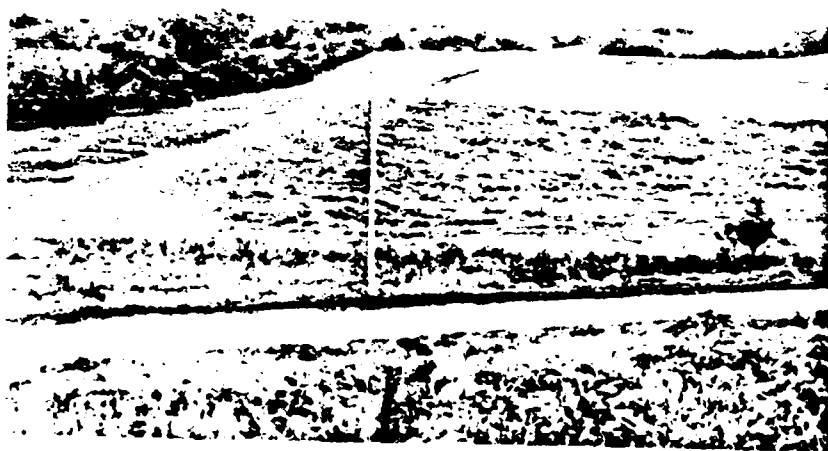


PHOTO NO. 6
SEEP AT STA. 4+00



PHOTO NO. 7
DOWNSTREAM SLOPE
OF DAM FROM LEFT
ABUTMENT

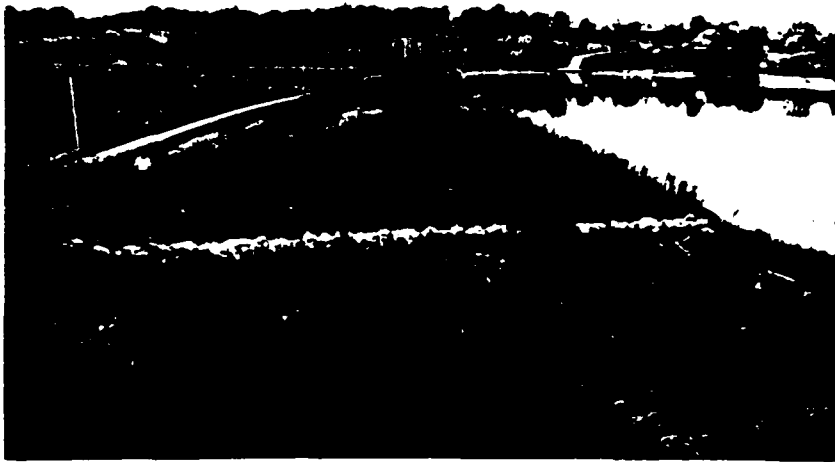


PHOTO NO. 8
ALONG CENTERLINE
FROM LEFT
ABUTMENT.



PHOTO NO. 9
LAKE FROM
LEFT ABUTMENT



PHOTO NO. 10
8" PIPE WITH
VALVE. APPROX.
STA. 2+10.

APPENDIX C
PLANS AND REPORTS

APPENDIX D
HYDROLOGIC COMPUTATIONS

HYDROLOGIC COMPUTATIONS

1. The Mockes dimensionless standard curvilinear unit hydrograph and the SCS TR-20 program were used to develop the inflow hydrographs (see Plates D1 and D2).

a. Forty-eight hour, 100 year rainfall for the dam location was obtained by applying the current OCE directives furnished 3 August, 1978 with various durational increments obtained from the 100-year rainfall tables taken from NOAA Technical Paper 40. The forty-eight hour probable maximum precipitation was taken from the curves of the Hydrometeorological Report No. 33 and current OCE directives mentioned previously.

b. Drainage area = 0.636 square miles (0.938 square miles total).

c. Time of concentration of runoff - 32 minutes.

d. The antecedent storm conditions were heavy rainfall and low temperatures which occurred on the previous 5 days (SCS AMC III). The initial pool elevation was assumed at the invert of the spillway.

e. The total forty-eight hour storm duration losses for the 100-year storm were 0.80 inches. The total losses for the forty-eight hour duration $\frac{1}{2}$ PMF storm were 0.75 inches. The total losses for the PMF storm were 1.21 inches. These data are based on the SCS runoff curve No. 92.8 and antecedent moisture conditions from SCS AMC III.

f. Average soil loss rates = 0.05 inch per hour approximately.

2. The primary and secondary spillway discharge ratings were developed using the concept of critical depth in the spillway control section and conservative head losses through the spillway entrance section (head loss = $0.1 H_v$), where H_v is the velocity head at the spillway control section.

The flows over the dam crest are based on the broad crested weir equation ($Q = CLH^{1.5}$), where H is the head on the dam crest; L is the effective weir length; the coefficient C is based on U.S. Geological Survey criteria. The discharge through the 8 inch diameter steel pipe was assumed not to contribute to the combined rating curve of the dam.

3. The probable Maximum Flood and fractions of it were routed through the dam to determine that percentage of PMF which just overtops the dam. This result was obtained by interpolating between 0.5 and 0.6 PMF routings respectively. It must be noted that Berndt Lake, (Mo 10472) discharges directly into Twin Lake, and Twin Lake discharges directly into Hidden Valley (Mo 10665). Because of this, all three dams, as well as Lake Marie Dam (Mo 10154) were routed together. The routings were made using the

SCS TR-20 program. The 100-year flood was also routed through the dams. The input rainfall distributions, reservoir inflow hydrographs, and outflow hydrographs are shown on Plates D1 and D2 for the PMF, $\frac{1}{2}$ PMF, and 100 year flood. The percentage of PMF just overtopping was not plotted because of the $\frac{1}{2}$ PMF being so close to the percent overtopping.

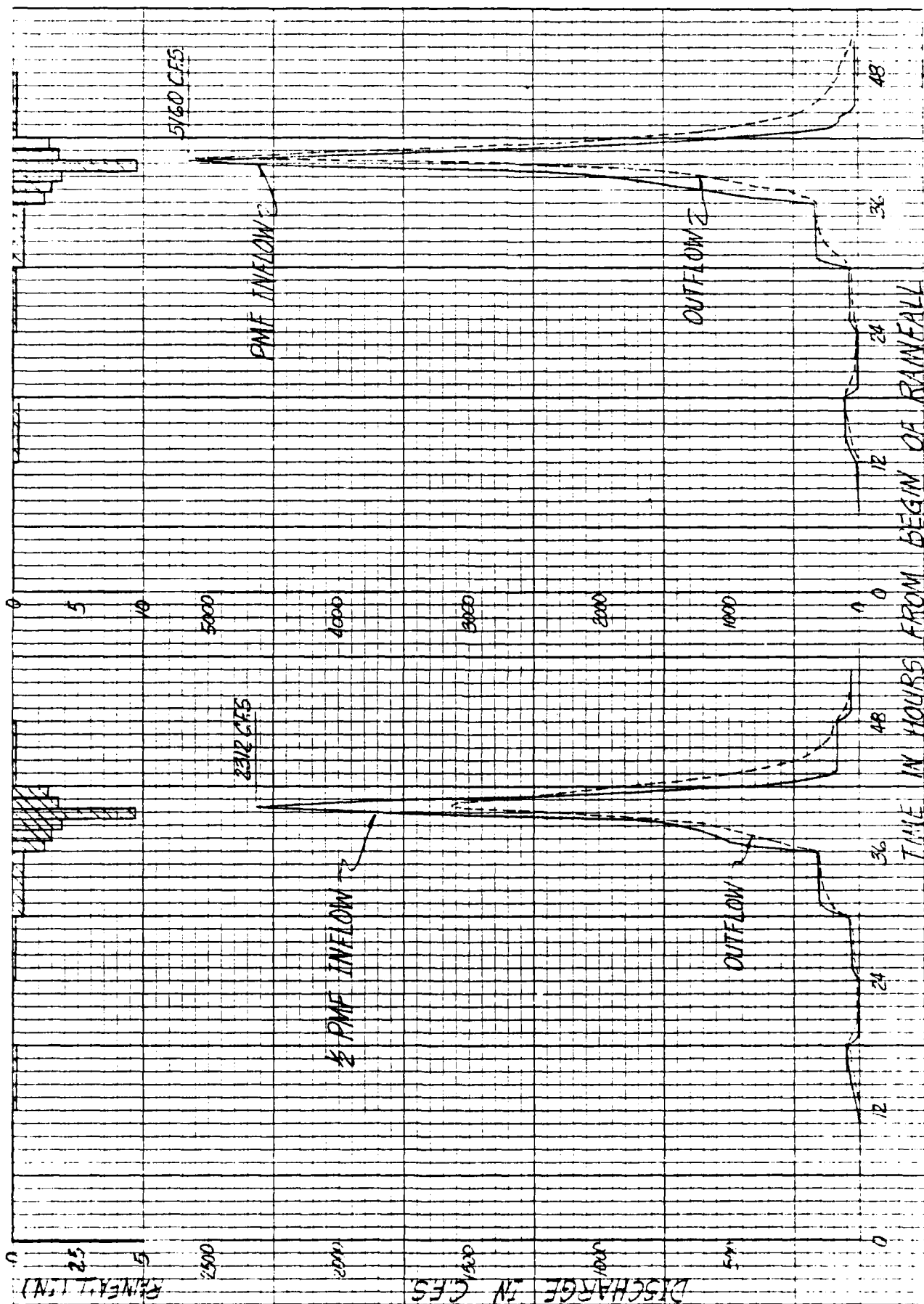


PLATE DI

